(b) Comparison of assumptions to specific, pertinent on-site conditions
(c) Comparison of input parameter values to pertinent on-site conditions
(d) Review of maintenance and testing documentation to ensure adherence to the schedules detailed in the facility's O&M manual

(5) Reconciliation of discrepancies as follows:

(a) A listing of discrepancies
(b) Consultation with the facility owner and/or their representative
(c) Preparation of a schedule that reconciles the discrepancies

A.10.1.11 Private fire inspection services can be used to meet this provision provided that they are qualified to assess the impact of changes on the performance-based design and assumptions.

A.10.2.2 The performance criteria in Section 10.2 define an acceptable level of performance that should be agreed upon by the stakeholders, including the owner and the AHJ. The acceptable level of performance can vary widely between facilities based on a number of factors, including the existence of potential ignition sources, potential fuel loads present, reactivity and quantity of hazardous materials present, the nature of the operations conducted at the facility, and the characteristics and number of personnel likely to be present at the facility.

A.10.2.2.1 Many of the performance criteria related to safety from fire can also be found in the annex of NFPA *101.*

A.10.2.2.2 It is anticipated that the design provides protection for occupants who are not intimate with the initial unintentional detonation or deflagration of explosive materials, and individuals immediately adjacent to the property. It is recognized that employees should be trained and knowledgeable in the hazards of the materials present in the workplace. It is recognized that some of these individuals could experience psychological and physical injuries, such as hearing problems, on either a short or long term basis. However, the intent is that they do not experience thermal burns or loss of life or limb as a direct result of the explosion.

It is not the intent of the code to provide protection against explosions caused by acts of terrorism. This would involve the introduction of an unknown quantity of explosives in an unknown location within or adjacent to a building. Where protection is needed against such acts of terrorism, the appropriate military and law enforcement agencies should be consulted.

A.10.2.2.3 Given the nature and variety of hazardous materials, more than one performance criterion for a specific facility could need to be developed. Criteria have to be developed for each hazardous material and possibly for different personnel; for example, higher levels of exposure can be tolerated by personnel that are in some way protected than those personnel having no protection. Development of performance criteria for hazardous materials should be developed by the facility owner and the facility's safety personnel in conjunction with the AHJ and the emergency response personnel expected to respond to an incident.

It is anticipated that the design provides protection for occupants inside or immediately adjacent to the facility who are not intimate with the initial unauthorized release of hazardous materials, or the initial unintentional reaction of hazardous materials. However, it is assumed that these individuals depart from the area of the incident in a time frame reasonable for their circumstances, based on their observation of the event, or some other form of notification.

It is also anticipated that employees and emergency response personnel are trained and aware of the hazardous materials present in the facility, and the potential consequences of their involvement in the incident, and take appropriate measures to ensure their own safety during search and rescue operations.

It is not the intent of the code to provide protection against acts of terrorism involving the introduction of hazardous materials into a facility. This involves the introduction of an unknown quantity of materials in an unknown location within or adjacent to a building. Where protection is needed against such acts of terrorism, the appropriate military and law enforcement agencies should be consulted.

A.10.2.2.4 Each facility designed using a performance-based approach most likely has different levels of acceptable and unacceptable property damage. This reflects the unique aspects of the performance-based designed facility and the reasons for pursuing a performance-based design. Therefore, the definition of an acceptable and an unacceptable level of property damage results from discussions between the facility's owner, manager and engineer, the designer, (possibly) the insurance underwriter and field engineer, and the AHJ. There could be cases where a property damage criterion is not needed.

Note that the structural integrity performance criteria for property damage most likely differ from the structural integrity performance criteria for life safety. This reflects the difference in the associated objectives: A life safety criterion probably is more restrictive than one for property damage.

A.10.2.2.5 Each facility designed using a performance-based approach most likely has a different level of acceptable and unacceptable interruption of the facility's mission. This reflects the unique aspects of the performance-based designed facility and the reasons for pursuing a performance-based design. Therefore, the definition of an acceptable and an unacceptable interruption of the facility's mission results from discussions between the facility's owner, manager and engineer, the designer, (possibly) the insurance underwriter and field engineer, and the AHJ. There could be cases where a mission continuity criterion is not needed.

A.10.3.2 In jurisdictions where NFPA electrical standards are not adopted, the provisions of the electrical standards adopted by the AHJ should be used.

A.10.3.4 In jurisdictions where NFPA *101* is not adopted, the provisions of the building code adopted by the AHJ should be used.

A.10.4 Many events can occur during the life of a facility; some have a higher probability of occurrence than others. Some events, though not typical, could have a devastating effect on the facility. A reasonable design should be able to achieve the goals, objectives, and performance criteria of this code for any typical or common design scenario and for some of the nontypical, potentially devastating scenarios, up to some level commensurate with society's expectations as reflected in this code.

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The challenge in selecting design scenarios is finding a manageable number that are sufficiently diverse and representative so that, if the design is reasonably safe for those scenarios, it should then be reasonably safe for all scenarios, except for those specifically excluded as being unrealistically severe or sufficiently infrequent to be fair tests of the design.

A.10.4.1.2 The *SFPE Engineering Guide to Performance-Based Fire Protection* identifies methods for evaluating fire scenarios.

A.10.4.1.3 It is desirable to consider a wide variety of different design scenarios to evaluate the complete capabilities of the building or structure. Design scenarios should not be limited to one or two worst-case events.

A.10.4.2.1 An example of such a scenario for a health care occupancy is a patient room with two occupied beds with a fire initially involving one bed and the room door open. This is a cursory example in that much of the explicitly required information indicated in 10.4.2.1 can be determined from the information provided in the example. Note that it is usually necessary to consider more than one scenario to capture the features and conditions typical of an occupancy.

A.10.4.2.2 Examples of such scenarios are a fire involving ignition of gasoline as an accelerant in a means of egress, clothing racks in corridors, renovation materials, and other fuel configurations that can cause an ultrafast fire. The means of egress chosen is the doorway with the largest egress capacity among doorways normally used in the ordinary operation of the building. The baseline occupant characteristics for the property are assumed. At ignition, doors are assumed to be open throughout the building.

A.10.4.2.3 An example of such a scenario is a fire in a storage room adjacent to the largest occupiable room in the building. The contents of the room of fire origin are specified to provide the largest fuel load and the most rapid growth in fire severity consistent with the normal use of the room. The adjacent occupiable room is assumed to be filled to capacity with occupants. Occupants are assumed to be somewhat impaired in whatever form is most consistent with the intended use of the building. At ignition, doors from both rooms are assumed to be open. Depending on the design, doorways connect the two rooms or they connect via a common hallway or corridor.

For purposes of this scenario, an occupiable room is a room that could contain people (i.e., a location within a building where people are typically found).

A.10.4.2.4 An example of such a scenario is a fire originating in a concealed wall- or ceiling-space adjacent to a large, occupied function room. Ignition involves concealed combustibles, including wire or cable insulation and thermal or acoustical insulation. The adjacent function room is assumed to be occupied to capacity. The baseline occupant characteristics for the property are assumed. At ignition, doors are assumed to be open throughout the building.

A.10.4.2.5 An example of such a scenario is a cigarette fire in a trash can. The trash can is close enough to room contents to ignite more substantial fuel sources but is not close enough to any occupant to create an intimate-with-ignition situation. If the intended use of the property involves the potential for some occupants to be incapable of movement at any time, then the room of origin is chosen as the type of room likely to have such occupants, filled to capacity with occupants in that condition. If the intended use of the property does not involve the potential for some occupants to be incapable of movement, then the room of origin is chosen to be an assembly or function area characteristic of the use of the property, and the trash can is placed so that it is shielded by furniture from suppression systems. At ignition, doors are assumed to be open throughout the building.

A.10.4.2.6 An example of such a scenario is a fire originating in the largest fuel load of combustibles possible in normal operation in a function or assembly room or in a process/manufacturing area, characteristic of the normal operation of the property. The configuration, type, and geometry of the combustibles are chosen so as to produce the most rapid and severe fire growth or smoke generation consistent with the normal operation of the property. The baseline occupant characteristics for the property are assumed. At ignition, doors are assumed to be closed throughout the building.

This scenario includes everything from a big couch fire in a small dwelling to a rack storage fire in combustible liquids stock in a big box retail store.

A.10.4.2.7 An example of such a scenario is an exposure fire. The initiating fire is the closest and most severe fire possible consistent with the placement and type of adjacent properties and the placement of plants and combustible adornments on the property. The baseline occupant characteristics of the property are assumed.

This category includes wildland/urban interface fires and exterior wood shingle problems, where applicable.

A.10.4.2.8 This scenario addresses a set of conditions with a typical fire originating in the building with any one passive or active fire protection system or feature being ineffective. Examples include unprotected openings between floors or between fire walls or fire barrier walls, rated fire doors that fail to close automatically or are blocked open, sprinkler system water supply that is shut off, a fire alarm system that is nonoperative, a smoke management system that is not operational, or automatic smoke dampers that are blocked open. This scenario should represent a reasonable challenge to the other building features provided by the design and presumed to be available.

The exemption from Fire Design Scenario 8 is applied to each active or passive fire protection system individually and requires two different types of information to be developed by analysis and approved by the AHJ. System reliability is to be analyzed and accepted. Design performance in the absence of the system is also to be analyzed and accepted, but acceptable performance does not require fully meeting the stated goals and objectives. It might not be possible to meet fully the goals and objectives if a key system is unavailable, and yet no system is totally reliable. The AHJ determines which level of performance, possibly short of the stated goals and objectives, is acceptable, given the very low probability (that is, the system's unreliability probability) that the system will not be available.

A.10.4.3.1 This scenario is intended to address facilities where explosives and products containing explosives are manufactured, stored, sold, or handled. From an overall safety standpoint, the operations being performed at these facilities should include stringent safety procedures that significantly reduce the likelihood of an explosion from occurring. However, if an explosion does occur, protection methods such as storage magazines, property set backs, deflagration, and explosion

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venting and containment need to be in place, as appropriate, to minimize potential injury and loss of life and property.

Where products containing explosives, such as pyrotechnic displays or fireworks, are stored, handled, or used in buildings, such as arenas, an explosion scenario should not result in significant injuries to occupants not intimate with the materials.

A.10.4.4 Design hazardous materials scenarios should explicitly account for the following:

(1) Occupant activities, training, and knowledge
(2) Number and location of occupants
(3) Discharge location and surroundings
(4) Hazardous materials' properties
(5) Ventilation, inerting, and dilution systems and conditions
(6) Normal and emergency operating procedures
(7) Safe shutdown and other hazard mitigating systems and procedures
(8) Weather conditions affecting the hazard
(9) Potential exposure to off-site personnel

Design hazardous materials scenarios should be evaluated as many times as necessary by varying the factors previously indicated. Design hazardous materials scenarios could need to be established for each different type of hazardous material stored or used at the facility.

A.10.4.4.4.2 This provision should be applied to each protection system individually and requires two different types of information to be developed by analysis and approved by the AHJ. System reliability is to be analyzed and accepted. Design performance in the absence of the system is also to be analyzed and accepted, but acceptable performance does not require fully meeting the stated goals and objectives. It might not be possible to meet fully the goals and objectives if a key system is unavailable, and yet no system is totally reliable. The AHJ determines which level of performance, possibly short of stated goals and objectives, is acceptable, given the very low probability (that is, the systems' unreliability probability) that the system will be unavailable.

A.10.4.5.1 An example of such a scenario would involve a fire or earthquake effectively blocking the principal entrance/exit but not immediately endangering the occupants. The full occupant load of the assembly space has to exit using secondary means.

A.10.6 The assessment of precision required in 10.7.7 requires a sensitivity and uncertainty analysis, which can be translated into safety factors.

Sensitivity Analysis. The first run a model user makes should be labeled as the base case, using the nominal values of the various input parameters. However, the model user should not rely on a single run as the basis for any performance-based fire safety system design. Ideally, each variable or parameter that the model user made to develop the nominal input data should have multiple runs associated with it, as should combinations of key variables and parameters. Thus, a sensitivity analysis should be conducted that provides the model user with data that indicates how the effects of a real fire could vary and how the response of the proposed fire safety design could also vary.

The interpretation of a model's predictions can be a difficult exercise if the model user does not have knowledge of fire dynamics or human behavior.

Reasonableness Check. The model user should first try to determine whether the predictions actually make sense; that is, they don't upset intuition or preconceived expectations. Most likely, if the results don't pass this test, an input error has been committed.

Sometimes the predictions appear to be reasonable but are, in fact, incorrect. For example, a model can predict higher temperatures farther from the fire than close to it. The values themselves could be reasonable; for example, they are not hotter than the fire, but they don't "flow" down the energy as expected.

A margin of safety can be developed using the results of the sensitivity analysis in conjunction with the performance criteria to provide the possible range of time during which a condition is estimated to occur.

Safety factors and margin of safety are two concepts used to quantify the amount of uncertainty in engineering analyses. Safety factors are used to provide a margin of safety and represent, or address, the gap in knowledge between the theoretically perfect model; that is, reality and the engineering models that can only partially represent reality.

Safety factors can be applied to either the predicted level of a physical condition or to the time at which the condition is predicted to occur. Thus, a physical or a temporal safety factor, or both, can be applied to any predicted condition. A predicted condition (that is, a parameter's value) and the time at which it occurs are best represented as distributions. Ideally, a computer fire model predicts the expected or nominal value of the distribution. Safety factors are intended to represent the spread of these distributions.

Given the uncertainty associated with data acquisition and reduction, and the limitations of computer modeling, any condition predicted by a computer model can be thought of as an expected or nominal value within a broader range. For example, an upper layer temperature of 1110°F (600°C) is predicted at a given time. If the modeled scenario is then tested (that is, full-scale experiment based on the computer model's input data), the actual temperature at that given time could be 1185°F (640°C) or 1085°F (585°C). Therefore, the temperature should be reported either as 1110°F, +75°F or −25°F (600°C, +40°C or −15°C) or as a range of 1085°F to 1184°F (585°C to 640°C).

Ideally, predictions are reported as a nominal value, a percentage, or an absolute value. As an example, an upper layer temperature prediction could be reported as 1112°F (600°C), 86°F (30°C), or 1112°F (600°C), 5 percent. In this case, the physical safety factor is 0.05 (i.e., the amount by which the nominal value should be degraded and enhanced). Given the state-of-the-art of computer fire modeling, this is a very low safety factor. Physical safety factors tend to be on the order of tens of percent. A safety factor of 50 percent is not unheard of.

Part of the problem in establishing safety factors is that it is difficult to state the percentage or range that is appropriate. These values can be obtained when the computer model predictions are compared to test data. However, using computer fire models in a design mode does not facilitate this since (1) the room being analyzed has not been built yet and (2) test scenarios do not necessarily depict the intended design.

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A sensitivity analysis should be performed based on the assumptions that affect the condition of interest. A base case that uses all nominal values for input parameters should be developed. The input parameters should be varied over reasonable ranges, and the variation in predicted output should be noted. This output variation can then become the basis for physical safety factors.

The temporal safety factor addresses the issue of when a condition is predicted and is a function of the rate at which processes are expected to occur. If a condition is predicted to occur 2 minutes after the start of the fire, then this can be used as a nominal value. A process similar to that described for physical safety factors can also be employed to develop temporal safety factors. In this case, however, the rates (e.g., of heat release and toxic product generation) will be varied instead of absolute values (e.g., material properties).

The margin of safety can be thought of as a reflection of societal values and can be imposed by the AHJ for that purpose. Since the time for which a condition is predicted is most likely the focus of the AHJ (e.g., the model predicts occupants have 5 minutes to safely evacuate), the margin of safety is characterized by temporal aspects and tacitly applied to the physical margin of safety.

Escaping the harmful effects of fire (or mitigating them) is, effectively, a race against time. When assessing fire safety system designs based on computer model predictions, the choice of an acceptable time is important. When an AHJ is faced with the predicted time of untenability, a decision needs to be made regarding whether sufficient time is available to ensure the safety of facility occupants. The AHJ is assessing the margin of safety. Is there sufficient time to get everyone out safely? If the AHJ feels that the predicted egress time is too close to the time of untenability, then the AHJ can impose an additional time that the designer has to incorporate into the system design. In other words, the AHJ can impose a greater margin of safety than that originally proposed by the designer.

A.10.7.1 The *SFPE Engineering Guide to Performance-Based Fire Protection* describes the documentation that should be provided for a performance-based design.

Proper documentation of a performance design is critical to the design acceptance and construction. Proper documentation also ensures that all parties involved understand what is necessary for the design implementation, maintenance, and continuity of the fire protection design. If attention to details is maintained in the documentation, then there should be little dispute during approval, construction, startup, and use.

Poor documentation could result in rejection of an otherwise good design, poor implementation of the design, inadequate system maintenance and reliability, and an incomplete record for future changes or for testing the design forensically.

A.10.7.2 The sources, methodologies, and data used in performance-based designs should be based on technical references that are widely accepted and used by the appropriate professions and professional groups. This acceptance is often based on documents that are developed, reviewed, and validated under one of the following processes:

(1) Standards developed under an open consensus process conducted by recognized professional societies, codes or standards organizations, or governmental bodies
(2) Technical references that are subject to a peer review process and published in widely recognized peer-reviewed journals, conference reports, or other publications
(3) Resource publications such as the *SFPE Handbook of Fire Protection Engineering*, which are widely recognized technical sources of information

The following factors are helpful in determining the acceptability of the individual method or source:

(1) Extent of general acceptance in the relevant professional community. Indications of this acceptance include peer-reviewed publication, widespread citation in the technical literature, and adoption by or within a consensus document.
(2) Extent of documentation of the method, including the analytical method itself, assumptions, scope, limitations, data sources, and data reduction methods.
(3) Extent of validation and analysis of uncertainties. This includes comparison of the overall method with experimental data to estimate error rates as well as analysis of the uncertainties of input data, uncertainties and limitations in the analytical method, and uncertainties in the associated performance criteria.
(4) Extent to which the method is based on sound scientific principles.
(5) Extent to which the proposed application is within the stated scope and limitations of the supporting information, including the range of applicability for which there is documented validation. Factors such as spatial dimensions, occupant characteristics, and ambient conditions can limit valid applications.

In many cases, a method is built from and includes numerous component analyses. These component analyses should be evaluated using the same factors that are applied to the overall method as outlined in items (1) through (5).

A method to address a specific fire safety issue, within documented limitations or validation regimes, might not exist. In such a case, sources and calculation methods can be used outside of their limitations, provided that the design team recognizes the limitations and addresses the resulting implications.

The technical references and methodologies to be used in a performance-based design should be closely evaluated by the design team and the AHJ, and possibly by a third-party reviewer. The strength of the technical justification should be judged using criteria in items (1) through (5). This justification can be strengthened by the presence of data obtained from fire testing.

A.10.7.11 Documentation for modeling should conform to ASTM E1472, *Standard Guide for Documenting Computer Software for Fire Models*, although most, if not all, models were originally developed before this standard was promulgated.

A.11.1.1 Determine the classification of ammonium nitrate in accordance with Chapter 4. Chapter 11 takes precedence to address the specific requirements for solid and liquid ammonium nitrate, when 1,000 lb is exceeded. The physical hazards of ammonium nitrate are dependent on the properties of the specific material or mixture of materials as a whole. Where used as a fertilizer, it is common for ammonium nitrate to exist as a component of a chemical mixture. It is not uncommon for the user to describe the mixture as ammonium nitrate when in reality the mixture can contain components that contribute to

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altering the end classification of the material. The manufacturer's safety data sheet (SDS) should be used to assess the overall hazards of these materials. The user is cautioned that the DOT shipping classification for transportation purposes alone is not a sufficient means by which to determine the storage and use hazards of these materials. Ammonium nitrate in the undiluted or pure form has a higher degree of overall hazard than does ammonium nitrate when mixed or blended with compatible materials that can reduce the concentration. The tables in Chapter 5 are hazard specific; they are not chemical specific. Ammonium nitrate as such is not included in the tables, because the actual hazard classification varies with the material under consideration. The question must be answered as to whether the material is an oxidizer, and, if so, what Class; whether it is an unstable reactive, and, if so, what Class; or whether there are other physical or health hazards attendant to the mixture under evaluation. *(See Annex E for additional information.)*

A.11.1.1.5 Ammonium nitrate and ammonium nitrate–based materials that are DOT Hazard Class 1 explosives should be stored in accordance with the requirements of NFPA 495. Sensitivity is determined by the application of the UN Test Series 1, which includes testing to determine impact sensitivity, friction sensitivity, sensitivity to electrostatic discharge, and thermal stability.

A.11.1.1.6 Agricultural application refers to the actual transporting and spreading of the fertilizers in fields. Storage in a building for eventual agricultural use is not an agricultural application.

A.11.1.4.9.1 This requirement is intended to prohibit floor drains, traps, tunnels, pits, or pockets into which any molten ammonium nitrate is able to flow and be confined in the event of fire.

A.11.1.4.9.2 The slope of the storage floor should be pitched in such a manner that it drains away from the ammonium nitrate pile and toward a containment area. As noted in other sections, no drainage pits, sumps, or confined piping should be designed into this drainage plan.

A.11.1.5 Where a documented risk analysis demonstrates to the AHJ that an equivalent level of fire safety can be achieved using alternatives to the requirements of this section, such an approach is an acceptable alternative. The risk analysis should be submitted to the AHJ in accordance with the requirements of 1.5.3. A risk analysis report should demonstrate equivalent fire safety by addressing relevant topics, including, but not limited to, the following:

(1) Location of the facility
(2) Distance to exposed structures and population density of public areas and other areas associated with the ammonium nitrate facility.
(3) Construction type
(4) Storage configuration
(5) Exposing combustible materials
(6) Emergency response capability
(7) Water supply
(8) Ammonium nitrate mixtures, blends, and uses
(9) Fire protection features provided (fire barriers, fire detection and alarm, and so on)

A.11.2.1 Sumps and collection systems as required by 6.2.1.9.2 create confinement conditions and should be avoided with molten ammonium nitrate, which could be created in a fire.

A.11.2.3 Storage of ammonium nitrate prills at ambient temperature [up to 140°F (60°C)] does not create decomposition products to a level that would create hazards to personnel and is not sufficient to catalyze higher rates of decomposition and uncontrolled heating.

Ammonium nitrate storage facilities do not purposefully bring fresh air into buildings since ammonium nitrate is a hygroscopic material. Constant exposure to humid air leads to caking, product degradation, and breakdown. Some facilities, especially large manufacturing sites, use dehumidification to prevent moist air from contacting ammonium nitrate solids. Most retail facilities are substantially open to outside air (i.e., naturally ventilated and not mechanically refreshed with ambient air).

The following is stated in "Summary Report: Workshop on Ammonium Nitrate" from the European Commission's Joint Research Center:

"Pure ammonium nitrate can undergo thermal decomposition if it receives enough energy. Gases are then emitted, especially nitrogen oxides and ammonia, both toxic. With proper ventilation, the decomposition stops as soon as the energy flow stops. The decomposition rate is not dangerously high at moderate temperatures, and the overall thermal effect is not significant since the exothermic reactions are accompanied by endothermic disassociation..."

Providing ventilation for severely contaminated product would not be practical because an appropriate hazardous gas production rate cannot be realistically predicted. Ventilation for fire conditions involving ordinary combustibles that are adequately controlled by automatic sprinklers has not been shown to have a significant effect on control of the fire.

The proper loss prevention approach is to prevent product contamination and either to eliminate combustible construction or occupancy (preferred) or to control burning combustibles by providing adequate automatic sprinkler protection.

A.11.2.5 It is not the intent to apply the requirements of 11.2.5, 11.2.7, or 11.2.8 to new or existing buildings of Type I and Type II construction storing only bulk ammonium nitrate.

A.11.2.5.1 Where existing or equivalent methods are intended to meet the retroactive criteria, suitable documentation should be submitted to the AHJ *(see 1.5.1 and 1.5.2)*. The documentation should follow the guidelines outlined in the performance-based option *(see Chapter 10)* focused on the specific alternative.

A.11.2.5.3 Foam, dry-chemical, or gaseous extinguishing systems are ineffective in controlling fires involving ammonium nitrate, which is an oxidizer that supplies its own oxygen. Steam is similarly ineffective and should not be used due to the addition of heat to the decomposing mass. Water cools the ammonium nitrate and reduces molten ammonium nitrate formation and decomposition.

A.11.2.7.2 When first responders arrive at the facility after the emergency communications center has alerted them of activation of the alarm, detection, or automatic fire extinguishing system, they will need to size-up the situation and determine if the public notification/siren system needs to be activated.

A.11.2.11 Explosion control methods required by 6.2.1.6 are not warranted for ammonium nitrate regulated by this chapter. Deflagration control methods described in NFPA 69 (primarily deflagration venting) are not effective for the detonations that

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can sometimes result from ammonium nitrate that is involved in a fire situation. In Chapter 11, the emphasis is on explosion prevention, but using methods that will be effective on ammonium nitrate and not those required by NFPA 69 — namely combustible concentration reduction, oxidant concentration reduction, and deflagration control. The other requirements of Chapter 11 are intended to prevent ammonium nitrate explosions and are more effective than the requirements of 6.2.1.6 for this material. Ammonium nitrate that is formulated to be an explosive is regulated in accordance with NFPA 495 and not this chapter.

A.11.2.16.1.1 Provisions should be made to avoid the following conditions with ammonium nitrate:

(1) Heating in a confined space
(2) Localized heating potentially leading to development of high-temperature areas
(3) Exposure to strong shock waves
(4) Contamination with combustible materials or incompatible inorganic and organic substances that can result in sensitivity to explosion.
(5) Low pH or acidic conditions

A.11.2.17 A pre-incident best practices plan should be developed by the local fire department in conjunction with any facility that stores, uses, or handles ammonium nitrate. NFPA 1620 can be used for further guidance.

A.11.2.17.1.3 A 1-mile (1.6 km) public evacuation distance has been recommended in the rare event of a facility containing ammonium nitrate becoming involved in a fire. This evacuation distance is recommended because the exact conditions of a facility during the emergency might not be known to the emergency response personnel. Under these potentially unknown conditions a worst-case scenario is assumed to ensure the public is evacuated to a safe distance. These unknown conditions can include the following:

(1) The condition of the ammonium nitrate involved in the fire. For example, contamination from a material that can behave as a fuel could potentially lead to a more violent release of energy than uncontaminated ammonium nitrate.
(2) Presence of a burning structure.
(3) The quantity of ammonium nitrate involved in the fire.

Overpressure calculations alone are not adequate to determine evacuation distances and debris field modeling is necessary to help ensure public safety. The 1-mile (1.6 km) distance is based on a quantitative risk analysis of a scenario that involves ammonium nitrate mixed with a fuel source and the presence of a burning structure. Quantities up to one million pounds (453,592 kg) of ammonium nitrate were used in the determination based on projectile travel distance.

A.11.2.18 NFPA 704 currently lists ammonium nitrate under emergency conditions as Health = 0, Flammability = 0, Instability = 3, and Other = OX (oxidizer). Safety data sheets that provide NFPA 704 ratings typically agree with all ratings except Health where ratings of 0, 1, or 2 are reported by different manufacturers. Because decomposition products include various nitrogen oxides (NOx) and nitric acid, the minimum health rating should be considered 1.

A.11.3.1.2 Housekeeping information can be found in *Safety and Security Guidelines for the Storage and Transportation of Fertilizer Grade Ammonium Nitrate at Fertilizer Retail Facilities,* and EPA 550-F-15-001, *Chemical Advisory: Safe Storage, Handling, and Management of Solid Ammonium Nitrate Prills.*

A.11.3.2.3.1 Wood impregnated with ammonium nitrate is a fire hazard. It can be ignited by a low-energy source with a vigorous fire.

A.11.3.2.3.4 Metal bins can be protected by special coatings such as sodium silicate, epoxy coatings, or polyvinyl chloride (PVC) coatings.

A.11.3.2.3.5 Storage in aluminum transport vehicles is not recommended.

A.11.3.2.3.9 Bulk and bagged ammonium nitrate can become caked and degrade in storage. This is a factor affected by humidity and temperature in the storage space and by prill quality. Temperature cycles through 90°F (32°C) and high atmospheric humidity are undesirable for storage in depth.

A.11.4.3.3 Active loading or unloading of vehicles with ammonium nitrate from the hoppers/bins is not considered parking and is permitted. The vehicle operator should remain within 25 ft (7.6 m) of the vehicle during loading or unloading operations. Immediately upon completion of the loading/unloading activity, the vehicle should be moved at least 30 ft (9.1 m) away from the hopper/bins.

A.11.4.5 Many of the general principles for the storage of ammonium nitrate–based fertilizers apply equally to fertilizers stored in the open and those stored in a building. It is generally recommended that bagged ammonium nitrate fertilizers should not be stored in large piles outdoors.

It should be noted that repeated temperature cycles can cause physical deterioration of some products. Physical deterioration can result in the breakdown of the fertilizer particles and damage to packages. The product should be protected from direct sunlight. Due note should be taken of ground conditions when storing outdoors to avoid damage to the product. Outdoor storage areas should be protected against unauthorized access, for example, by means of a fence. Warnings against unauthorized entry should be posted.

A.11.5.5.1 Foam, dry-chemical, or gaseous extinguishing systems are ineffective in controlling fires involving ammonium nitrate, an oxidizer that supplies its own oxygen. Steam is similarly ineffective.

A.11.8.1.1.1 This includes battery-powered vehicles and vehicles powered by internal combustion engines such as motor vehicles, lift trucks, and cargo conveyors. It is recommended that electric or LP-Gas–powered trucks be employed rather than gasoline- or diesel to reduce the potential for contamination to ammonium nitrate. *(See A.11.4.3.3.)*

A.11.8.1.2 Examples of hollow spaces include hollow conveyor rollers and hollow screw conveyor shafts.

A.14.1.1 The classification system for organic peroxides is package and burn rate dependent. To address the scope of NFPA 400 for storage, use and handling of each organic peroxide formulation is to be classified with respect to quantity and type of container based upon testing performed to reach a transport classification. Classification should be done by professionals familiar with the properties of the organic peroxide formulation. Property information used for classification of organic peroxide formulations for UN Transportation of Dangerous Goods can be useful for the NFPA 400 classification.

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Additionally the small-scale and sometimes large-scale burn rate data from actual experiments are used, in addition to the transport classification, to reach the storage classification. Other useful information includes density, small fire test data, and fire data for response to sprinkler conditions. For further guidance, see Annex F.

A.14.1.2 For information on combustible or limited-combustible construction, see NFPA 220.

A.14.2.4 In the venting equation, use the fuel characteristic constant for "gases with fundamental burning velocity less than 1.3 times that of propane." See NFPA 68 for information on vent design. Refer to manufacturers' technical data for information on organic peroxide formulations that give off flammable gases upon decomposition.

A.14.2.5.1 Fire protection systems for material in containers other than original DOT packaging, including bulk tanks, and materials in the unpackaged state should be designed by design professionals familiar with the nature of the product under fire conditions.

A.14.2.5.4 Dry pipe and double-interlock preaction (DIPA) sprinkler systems are not permitted for protection of buildings or areas containing Class I through Class III organic peroxide formulations, except as noted in 14.2.5.4.1. These formulations generally have a fast burning rate and high-heat release rate, requiring a quick response and immediate discharge of water from the sprinklers. Dry pipe and DIPA sprinkler systems generally result in delayed discharge of water when sprinkler activation occurs.

A.14.2.10.8 The method of disposal can vary depending on the specific formulation and materials with which they might have been contaminated. Refer to the manufacturer or the supplier of the specific formulation for advice.

A.14.3.2 The classification system described in Section 4.1 is used only to determine the storage requirements established by this code. It is not meant to be a substitute for the hazard identification system established by NFPA 704. Since the hazard characteristics of organic peroxide formulations vary widely depending on the type of organic peroxide, the diluent, and their relative concentrations, each specific formulation will have to be rated individually according to the criteria established in NFPA 704.

For the purpose of this document, an important building is one that is occupied or that contains facilities vital to the operation of the plant.

A.14.3.2.4 In the venting equation, use the fuel characteristic constant for "gases with fundamental burning velocity less than 1.3 times that of propane." See NFPA 68 for information on vent design. Refer to manufacturers' technical data for information on organic peroxide formulations that give off flammable gases upon decomposition.

A.14.3.2.5 For example, a sprinklered building, detached by 50 ft (15.3 m), can contain up to 500 lb (227 kg) of Class I, 50,000 lb (22,700 kg) of Class II, and 50,000 lb (22,700 kg) of Class III formulations, according to the following ratios:

(1) Class I:

[A.14.3.2.5a]

$$\frac{500\text{ lb}}{2000\text{ lb (max)}}\times 100 = 25\% \qquad \frac{227\text{ kg}}{907\text{ kg (max)}}\times 100 = 25\%$$

(2) Class II:

[A.14.3.2.5b]

$$\frac{50{,}000\text{ lb}}{100{,}000\text{ lb (max)}}\times 100 = 50\% \qquad \frac{22{,}700\text{ kg}}{45{,}400\text{ kg (max)}}\times 100 = 50\%$$

(3) Class III:

[A.14.3.2.5c]

$$\frac{50{,}000\text{ lb}}{200{,}000\text{ lb (max)}}\times 100 = 25\% \qquad \frac{22{,}700\text{ lb}}{90{,}700\text{ lb (max)}}\times 100 = 25\%$$

In no case does the quantity in storage exceed the maximum for its class, nor does the sum of the percentages exceed 100 percent.

A.14.3.2.9.4 Since no commercially available Class I organic peroxide formulations are supplied in 55 gal (208 L) drums, there is no requirement for such storage.

A.14.3.4.3.1 A detached, mechanically refrigerated building for storing organic peroxide formulations that require temperature control is illustrated in Figure A.14.3.4.3.1.

A.14.3.4.3.3 Figure A.14.3.4.3.3 is an example of a nonrefrigerated building for storing less than 5000 lb (2270 kg) of organic peroxide formulations for detached storage as allowed by 14.3.4.3.3.

A.14.5.7 Considerations should be given for maintaining proper refrigeration capability in the event of a loss of power. Some materials, when frozen, could cause separation of a carrier from the organic peroxide.

A.14.5.14.3 The method of disposal can vary depending on the specific formulation and materials.

A.15.1.4 In the manufacturing process, materials are collected and staged for transportation from manufacturing areas to a storage or warehouse location. Transient storage is intended to describe those materials being staged for transport. They are called transient while they are in the manufacturing area because they are not in their storage location. In the manufacturing location, finished goods can be found in a packaged state where they can be further palletized or otherwise arranged or collected awaiting transportation.

A.15.2.1.1 The NFPA *Fire Protection Guide to Hazardous Materials* should be used for guidance on compatibility.

A.15.2.1.2 Spill control, drainage, and containment are typically required under environmental regulations. Check the building code to determine whether it contains spill control requirements.

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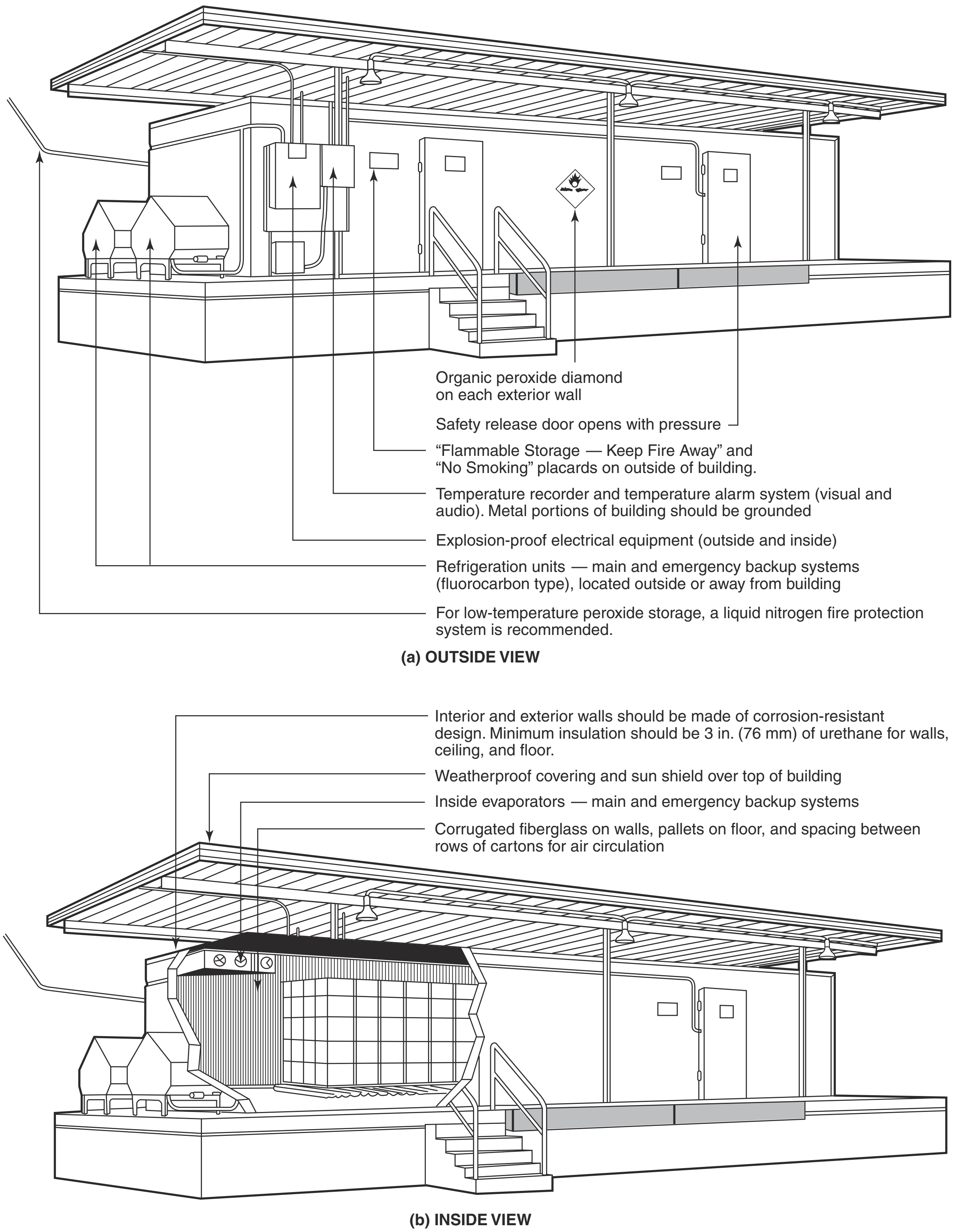

FIGURE A.14.3.4.3.1 Refrigerated Storage Building and Key Recommendations.

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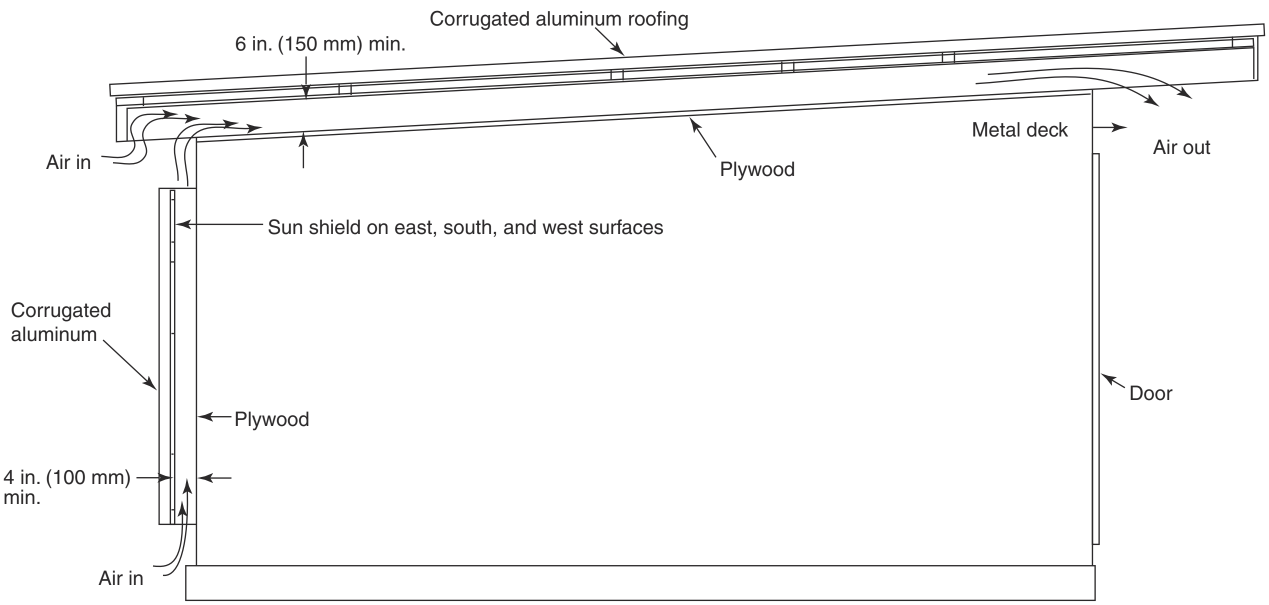

FIGURE A.14.3.4.3.3 Detached Storage Building for Storing Less than 5000 lb (2270 kg) of Organic Peroxide Formulations.

The decomposition of stored commercially available strengths of liquid and solid oxidizers can emit toxic gases. Additionally, the runoff from spills of stored oxidizers or from oxidizers mixed with fire-extinguishing agents can contain materials hazardous to the environment.

The hazards of stored oxidizers can manifest themselves in one or more of five distinct hazardous situations as follows:

(1) They can increase the burning rate of combustible materials.
(2) They can cause spontaneous ignition of combustible materials.
(3) They can decompose rapidly.
(4) They can liberate hazardous gases.
(5) They can undergo self-sustained decomposition, which can result in an explosion.
(6) They can react explosively if mixed with incompatibles or in fire conditions.

A.15.2.5 Automatic sprinklers are an effective method to control fires involving oxidizers in conjunction with the other fire prevention requirements in the document.

A.15.2.5.1 Dry pipe and double-interlock preaction (DIPA) sprinkler systems are generally prohibited by 15.2.5.1.1 for use with oxidizers. In mercantile occupancies with open-air environments that are already protected by these types of systems as prescribed by other codes, it is considered acceptable to store quantities defined by this code, with the recognition that these commodities might not be adequately protected. Outside storage in this manner is preferred to inside storage.

A.15.2.5.2.1 Conditions that affect the need for hydrant protection include nearness of the exposures, size and construction of the building, amount and class of the oxidizer stored, and availability of public fire protection.

A.15.2.5.3.1 A dry-chemical fire-extinguishing agent containing ammonium compounds (such as some A:B:C agents) should not be used on oxidizers that contain chlorine and bromine. The reaction between the oxidizer and the ammonium salts in the fire-extinguishing agent can produce the explosive compound nitrogen trichloride (NCl_3). Carbon dioxide or other extinguishing agents that function by a smothering action for effective use are of no value in extinguishing fires involving oxidizers.

A.15.2.5.3.2 Halon extinguishers should not be used on fires involving oxidizers because they can react with the oxidizer.

A.15.2.5.3.3 Halocarbon clean agent extinguishers as identified in NFPA 2001 are chemically similar to Halon and unless proved different should be assumed to react with the oxidizer.

A.15.2.11 Care should be exercised because some oxidizers are mutually incompatible. Chlorinated isocyanurates and hypochlorites are examples of oxidizers that are incompatible. The NFPA *Fire Protection Guide to Hazardous Materials* lists many oxidizers and other materials that result in hazardous interactions.

A.15.2.11.10 This requirement to restrict exposure to water is not intended to apply to the application of fire protection water.

A.15.2.11.11 Where absorptive combustible packing materials used to contain water-soluble oxidizers have become wet during either fire or nonfire conditions, the oxidizer can impregnate the packing material. This creates a serious fire hazard when the packing material dries. Wooden pallets that are exposed to water solutions of an oxidizer also can exhibit this behavior.

A.15.3.2.1.1 Impregnation of wood for fire retardancy or to prevent decay does not protect the wood from impregnation by the oxidizer.

A.15.3.2.2.2.2(A) Figure A.15.3.2.2.2.2(A) shows an example of a storage layout in a typical sprinklered warehouse.

A.15.3.2.2.3 The term *commodity* is used as defined in NFPA 13.

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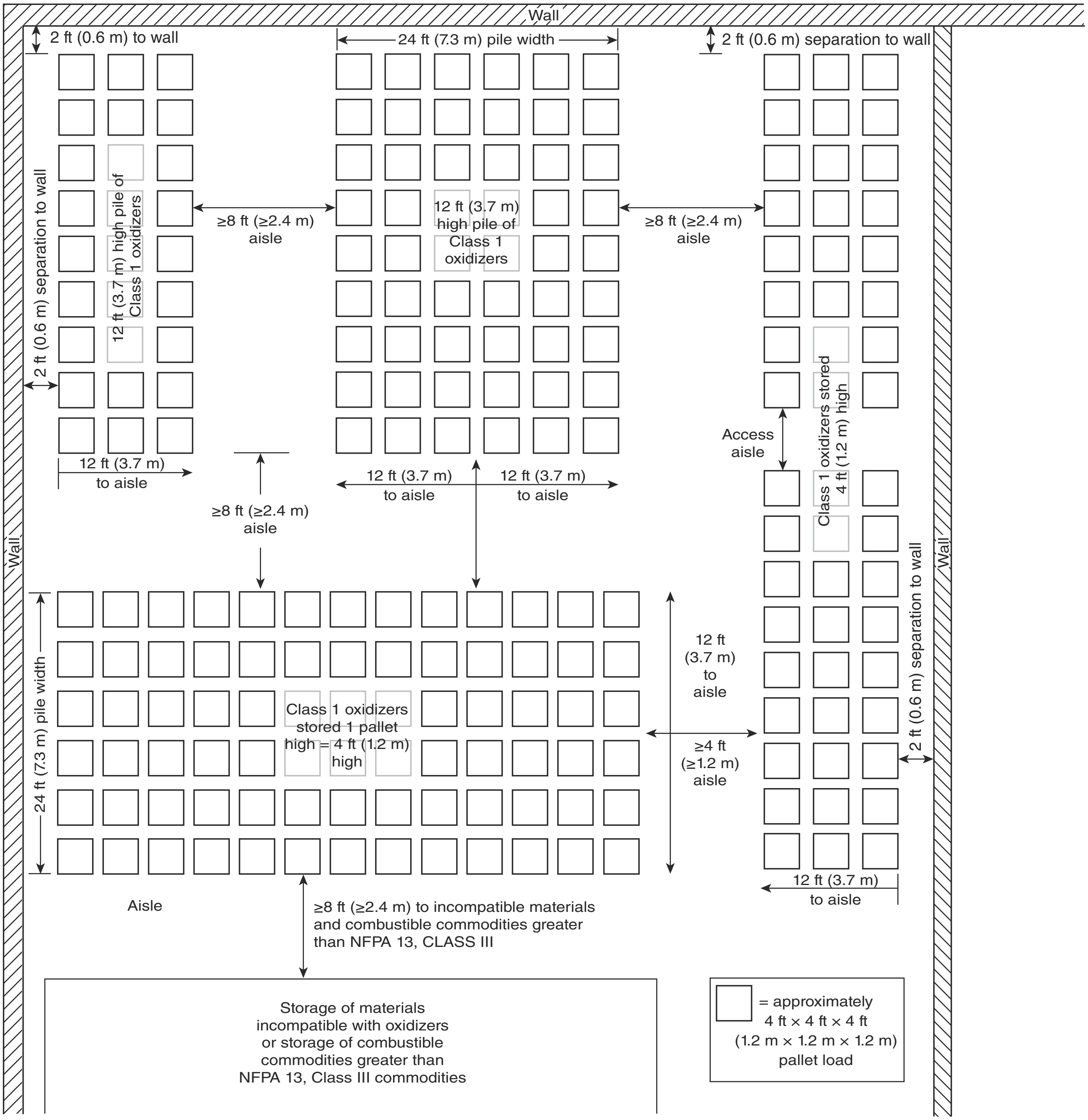

FIGURE A.15.3.2.2.2.2(A) Sample Layout for Class 1 Oxidizers in Sprinklered Buildings.

A.15.3.2.3.2.7 Only the building limit, not the pile limit, height, or width, can be increased by this provision.

A.15.3.2.5.4.5 For example, two tanks containing 4000 lb (1814 kg) and 3000 lb (1360 kg) of Class 4 oxidizer are separated by 25 ft (7.6 m). Because they are separated by less than 10 percent of 300 ft (92 m), the total quantity of 7000 lb (3175 kg) requires a minimum separation of 400 ft (122 m) to the nearest important structure in accordance with 15.3.2.5.3.4.

A.15.3.5.2.1 Recommended mercantile store arrangements for mutually incompatible oxidizers are shown in Figure A.15.3.5.2.1(a) and Figure A.15.3.5.2.1(b). These two diagrams illustrate arrangements that minimize the chance of exposure to incompatible materials. Wherever possible, vertical separation should be maintained between incompatible materials.

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